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TANK-MIX NICOTINE-BENTONITE FOR CONTROL OF THE CODLING MOTH

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Introduction

In the search for a program for applying some organic insecticide to control th codling moth that would equal in effectiveness the heavy spray schedules of lead arsenate at present required in areas of severe codling moth infestation, hundreds of tests of various fixed-nicotine combinations have been conducted by a number of State, Federal, and commercial investigators. The most promising of the combinations under investigation by the Vincennes, Ind., laboratory of the Bureau of Entomology and Plant Quarantine has been a tank mixture of nicotine sulphate, bentonite, soybean oil, and sodium lauryl sulphate. This has been tested for several years in laboratory-field experiments, and in 1937 gave favorable results when used by a Vincennes grower on 90 acres of his orchard. In 1938 five southern Indiana growers used it successfully on approximately 700 acres. Because of the interest aroused by the results obtained with this material, present available information is here summarized for the benefit of those growers who, on their own responsibility, wish to try it on a portion of their acreage.

Although the treatment is very promising and has given good results to date, further investigation of certain factors is necessary before full information will be available to local authorities for making their recommendations. Until the materials have been more extensively tested it is suggested that interested growers who have not already tried the treatment restrict its use to a small part of their orchard acreage.

Formula and Materials

Nicotine sulphate solution (40 percent nicotine)	1 pint
Wyoming bentonite	5 pounds
Soybean oil	1 quart
Water to make	100 gallons

Sodium lauryl sulphate, formerly included at 1/2 ounce per 100 gallons, has been omitted from the revised formula. It is a wetting agent which is available under several trade names, not all being the pure material. It was originally added partly because it appeared to increase the resistance of the deposits to weathering. Tests in 1938 indicate that this effect is measurable only when long periods elapse after an application, and further tests are

necessary before its value can be gauged accurately. The use of the pure material in quantities above 1/4 ounce per 100 gallons is likely to be detrimental by increasing the run-off.

Either raw powdered pure bentonite or the pellet form may be used. The latter is more easily wet because of its physical nature, and is identical in chemical composition with the raw powder. The bentonite should contain no wetting agent nor should it be treated chemically to assist wetting, as such treatment may destroy its desirable properties. Only "Wyoming" bentonite should be used.

The soybean oil used was the crude, domestic, raw form.

Method of Mixing

To mix the nicotine-bentonite, fill the tank with water to 3 or 4 inches above the top of the agitator blades, add the sodium lauryl sulphate, if used, and the nicotine sulphate, start the engine and agitators, pour the bentonite in very slowly, then add the soybean oil, and complete the filling with water. Do not stop the agitation during the mixing process. If the powdered form of bentonite is used, start with whatever volume of water will result in the most violent agitation.

The formula has been used without difficulty in both portable and stationary spray outfits and has been pumped as much as three-fourths of a mile in the latter.

Method of Spraying

This formula has little tendency to build a deposit beyond the point of run-off. In the early season its coverage will tend to be slightly blotchy, but after the second or third cover it usually produces a uniform film. By this time the deposit has become more conspicuous and the trees take on more of a whitewashed appearance except when wet. Disappearance of the white as wetting occurs aids materially in promoting efficient spraying. This phenomenon does not occur on trees sprayed with lead arsenate, the white showing through the wet film. Spraying should be continued to or slightly beyond the point where run-off begins, particular attention being paid to the tops, where the protection, as with any insecticide, weakens most rapidly.

Spray Program

For the grower who intends to try the combination the following program is outlined. This program is for the control of severe infestations on winter varieties in areas of long growing seasons. For more northern localities a shorter program must be worked out. For summer apples this tank-mix has been used successfully in the first two cover sprays without leaving excessive bentonite residues when they were followed by one or more applications of nicotine sulphate-mineral oil. Strict adherence to the formula is advised. It should be distinctly understood that this program is experimental.

Spray	When applied	Materials used in 100 gallons
Pre-bloom, calyx, and first cover sprays		Use program usually recommended. Omit the first cover if no curculio is present
Second cover	Complete immediately before first hatch of worms	Nicotine sulphate solution (40% nicotine), 1 pint; Wyoming bentonite, 5 pounds; soybean oil (crude domestic raw), 1 quart.
Third cover	Seven days after second cover	Same as for second cover.
Special top-off	Between third and fourth covers	Same as for second cover, but apply only to top third of trees.
Fourth cover	Ten days after third cover	Same as for second cover.
Fifth cover	Ten days after fourth cover	Same as for second cover.
Sixth cover	Complete immediately before second-brood worms start hatching	Nicotine sulphate solution, 2/3 pint; bentonite, 3 pounds; soybean oil, 1 quart.
Seventh cover	10 to 14 days after sixth cover	If equipped to wash in brush machine, same as sixth cover; otherwise 1 gallon summer oil emulsion; 2/3 pint nicotine sulphate, 1 pound bentonite.
Eighth cover	10 to 14 days after seventh cover	Same as seventh cover.
Third-brood spray	Usually first week in September	1 gallon summer oil, 2/3 pint nicotine sulphate solution.

After two or three cover sprays the trees will remain white as a result of the heavy bentonite deposit. If no further spraying is done, the nicotine in this deposit may gradually disappear after a period of time, leaving a conspicuous residue that is no longer toxic to the codling moth; hence the grower should not desist in his spray program because his trees appear to retain heavy spray deposits. As the apples reach a large size late in the season a particular effort should be made to cover thoroughly the calyx end of the fruit. The protection weakens first around the calyx, apparently because less nicotine is deposited there late in the season than elsewhere on the fruit.

The combination is more costly than a lead arsenate program, but the grower should guard against the temptation to skimp on material. The greatest efficiency from nicotine-bentonite as well as from lead arsenate

will be obtained where spraying is thorough and all parts of the tree and fruit are thoroughly wet.

Regardless of the amount of worm injury evident at the end of the first brood, the grower should give consideration to the fact that enough moths may emerge to cause serious worm injury later, even though at that time comparatively few apples are wormy. With any nicotine combination a third-brood spray will generally be necessary in regions having a growing season long enough to permit the development of a sizable third brood.

If the early spraying is thorough enough, sufficiently large reserve deposits may be built up by the first-brood cover sprays so that the proportions of nicotine sulphate and bentonite can later be reduced if three or four second-brood sprays are applied. This was the reason for the lower concentrations indicated in the tentative program outlined.

Residue

The nicotine-bentonite treatment frequently leaves a conspicuous residue at harvest time. A small quantity of nicotine may be present, but this gradually disappears from apples held for long periods in storage. If necessary, residues of nicotine may be removed by washing in any of the alkaline solutions commonly used for apple washing.

The residues of bentonite, although nonpoisonous, may be conspicuous enough to be objectionable. On some varieties dry brushing will effectively remove the bentonite residues, even when a full-season tank-mix schedule is used. On other varieties weak alkali washes may be necessary. The most satisfactory cold wash consists of 5 percent of sodium silicate and one-half of 1 percent of mineral oil. The machine should contain brushes somewhere in the line-up.

The use of oil sprays following applications of nicotine-bentonite tends to mask and soften the visible deposits of bentonite on some varieties, although this may not always eliminate the necessity for measures for residue removal. On varieties which produce considerable wax before harvest, late sprays of oil-nicotine do not aid removal, apparently because the bentonite is submerged in the wax. It is varieties of this type that are most difficult to clean. Light deposits of bentonite are somewhat masked during storage by the development of wax.

Effect of Fungicides and Other Sprays on Nicotine-Bentonite

When added to the nicotine-bentonite, any alkaline material immediately releases the nicotine from the combination. For this reason lime or bordeaux mixture cannot be used with the sprays, or even a few days before or after the application of nicotine-bentonite. Growers who must spray for blotch or bitter rot should therefore not consider using a nicotine schedule until effective and safe fungicides compatible with nicotine sprays are available. Those who use sulphur subsequent to the calyx spray should omit soybean oil from the first tank-mix application. Several of the so-called "neutral" copper fungicides have proved injurious to fruit or

foliage, and have also definitely depressed the efficiency of the tank-mix combination.

Tests have indicated that the use of split schedules where fixed nicotines are applied over deposits of lead arsenate-lime or of bordeaux mixture are not fully effective for the reason that the original deposits prevent the deposition of the usual amount of nicotine, and because the change-over is too often made in the middle of a brood, just when maximum effectiveness is needed. Instead of giving an additive effect, the different materials may affect one another unfavorably. This does not, however, appear to apply to the use of nicotine-oil following nicotine-bentonite. In fact, with the substitution of nicotine-sulphate and mineral oil in late-season sprays, the bentonite residue retains several times as much nicotine as occurs when similar oil-nicotine sprays are applied over lead arsenate deposits.

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